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DEPARTMENT OF COMMERCE

UNITED STATES BUREAU OF MINES
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INFORMATION CIRCULAR

PUMICE AND PUMICITE

BY

PAUL HATMAKER

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DEPARTMENT OF COMMERCE - BUREAU OF MINES

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By Paul Hatmaker[2]

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INTRODUCTION

Pumice and pumicite are siliceous volcanic substances quite similar in chemical composition, but somewhat different in physical properties, manner of formation, and mode of occurrence. Production in the United States has increased from 23,271 tons valued at $94,943 in 1910, to 56,843 tons valued at $336,099 in 1930. Both pumice and pumicite are included in these figures as it has been impractical to collect statistical data on the separate commodities.

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[1] - The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from U. S. Bureau of Mines Information Circular 6560."

[2] - Mining engineer, building materials section, U. S. Bureau of Mines.

Pumice occurs in California and Oregon, but much of the pumice consumed in the United States is imported from the island of Lipari near Sicily, either in pulverized form or as lump pumice which may be subsequently ground in this country. Pumice is used mainly as an abrasive. It is also used in construction as an insulating medium, as an aggregate in concrete and acoustic plaster, and in the manufacture of lightweight building units, the development of which is more extensive in Europe than in the United States.

Kansas and California produce most of the domestic pumicite, although relatively small quantities are mined in a few other States. Pumicite is used largely as an abrasive agent in scouring soaps and cleansing compounds, and as an admixture in concrete. It is used to some extent in various abrasive work as a substitute for pulverized pumice.

Assurance of adequate markets is an important consideration for prospective producers. Consumers usually buy abrasive material on the basis of experience as to its suitability to their own particular requirements and are seldom interested in new supplies so long as they are satisfied with that being used. Large tonnages for concrete work generally are bought on the basis of exhaustive preliminary tests on material from the most economical sources.

Pumice or pumicite from different deposits is rarely identical in physical properties. Variations in texture and composition affect the value of any particular deposit and must be fully investigated when new enterprises are being considered. Efficient abrasive material must be hard, sharp, and uniform in texture and particle size. Abrasive qualities depend to a considerable extent upon the shape of the individual particles. In many pumicite deposits the particles are flat or plate-shaped, and consequently tend to slide over a surface rather than to abrade it. This action naturally impairs the value of the material as an abrasive, but is an actual advantage in material used for cleansing and scouring compounds. The presence of sand grains, crystals of feldspar, or other foreign minerals is harmful because of the liability of a single grain to scratch polished surfaces ruinously. A like hazard exists with lump pumice having nonuniform texture or cell structure. In construction work, the chemical as well as the physical properties of the material are important.

Many deposits are erratic as to shape and extent. For this reason it is advisable to do considerable preliminary exploration work in order to make certain that a given deposit is large enough to warrant any extensive expenditures for equipment and development.

The preparation of pumice and pumicite for market appears to be simple, but producers must realize that the pumice and pumicite industry as a whole is highly specialized and that careful technical and scientific control in all departments is eminently worth while. Too little attention has been given in the past to this phase of the domestic industry, and undoubtedly this accounts, partly at least, for the present strong market position of imported material. As new uses continue to be developed, an even greater appreciation of utilization problems will be demanded from the producers.

Successful exploitation of new deposits, therefore, depends first upon markets; second, upon the ability to produce at a reasonable profit such material as will adequately satisfy specific market demands; and third, upon sufficient vision to evaluate, and courage to conform with, changing industrial conditions.

DEFINITION

Pumice is a cellular, glassy lava, usually similar in composition to a rhyolite. The term, as commonly applied, means material essentially unaltered since its formation.

Pumicite, on the other hand, is an accumulation of finely divided glass-like particles blown from volcanoes during periods of eruption and subsequently more or less classified while transported by winds. It may be wholly unconsolidated, or the individual particles may be more or less cemented together or agglomerated. Such material is also called volcanic dust, volcanic ash, tuff, and tufa. For this material the term "pumicite," however, is now commonly accepted throughout the industry, and is to be preferred to the term "volcanic ash" because such material is not the result of combustion. The use of tufa as a synonym for pumicite should be discouraged, because in correct usage tufa is a porous calcium carbonate deposited from solution.

Barbour[3] states that --

> Pumicite has been variously called geyserite, volcanic dust, volcanic ash, Gibson grit, diamond grit, native pumice, silica, and the like.*******For all of these we have substituted the name pumicite, a self-explanatory term, which we have used for some years. It is unfortunate that volcanic dust should ever have been known by the misleading term, "volcanic ash." However close the resemblance may be, it is not the product of combustion like ash, but instead is a powdered, glassy rock. In the outset it was known in Nebraska as geyserite, because supposedly produced by geysers. Survival of this conception is to be noted in Geyserite soap, which is made of pumicite. Of late pumicite has acquired the indefensible name of silica. Though a silicate, it is not silica, and should not be so called. It is natural glass, atomized by volcanic explosions. Block pumice, also natural glass, when atomized by machinery becomes the powdered pumice of commerce. Our beds of volcanic dust may be called native pumice, and the name pumicite seems appropriate and self-defining.

Tuff is a more inclusive term than pumicite and may be applied to fragmental pumice and to pumicite or other material explosively ejected from volcanoes. The pieces may be sorted or unsorted, consolidated or incoherent.

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3 - Barbour, Erwin H., Nebraska Pumicite: Nebraska Geol. Survey, vol. 4, pt. 27, 1916, p. 358.

DESCRIPTION

Appearance

Pumice looks like a glassy froth with innumerable vesicles or cavities, usually somewhat elongated and parallel one with another. In the better-grade deposits these congealed or solidified bubbles are quite uniform in size and character. Most pumice is white to gray, although certain varieties, because of impurities or a basic composition, may have other colors such as shades of red, yellow, brown, or black. Most pumice sparkles in bright sunlight but some varieties have an earthy appearance.

Pumicite, on the other hand, looks to the unaided eye like very fine closely-packed glassy sand. In the purer deposits the color is white to light or bluish gray; impurities, however, may cause a yellow, brown, or red stain. Minute sparkles are readily noted in bright sunlight. Magnified particles show marked angularity resembling powdered glass. Many are rather flat, others are triangular or dagger-shaped and some are four or five sided, still preserving, however, angular characteristics. Fluted structures parallel to the long axis are common. Most particles appear clear, but some grains are translucent and others exhibit an opaque ropy structure like fused glass.

Chemical Properties

Pumice and pumicite produced from acid magmas are similar in composition to many igneous rocks such as rhyolite and granite, and are composed mainly of silica in the form of complex silicates of aluminum, sodium, potassium, calcium, magnesium, and iron. Material of this nature is relatively inert chemically and does not effervesce in hydrochloric acid as do carbonates, a property sometimes helpful in identification. Material from some deposits may show an acid reaction with litmus, due probably to traces of sulphur dioxide.

An analysis of typical pumice and pumicite would show about the following chemical composition:

	Per cent
Silica (SiO_2)	72.0
Alumina (Al_2O_3)	14.0
Potash and soda (K_2O and Na_2O)	7.0
Lime and magnesia (CaO and MgO)	2.5
Iron oxide (Fe_2O_3 and FeO)	1.0
Loss upon ignition	3.5

Individual analyses vary somewhat from these figures and some material contains small quantities of other substances such as titanium oxide. Pumice from other than an acid magma would contain less silica and more iron oxide, lime, and other bases.

Physical Properties

For the individual particles or cell walls the hardness of pumice and pumicite is 5.5 to 6, or about as hard as feldspar and slightly softer than quartz. The true specific gravity is approximately 2.5, although the apparent specific gravity may be somewhat less. Lump pumice, because of its cellular structure, may even float readily on water, indicating a specific gravity of less than 1. The grains are brittle, but the sharpness persists even when finely pulverized. Mixed with water, pumicite settles, with no tendency to form a claylike suspension.

In texture, pumicite varies from loosely consolidated particles to flint-like material with the individual grains tightly cemented together. The size of individual fragments also varies considerably. Landes[4] lists 37 screen analyses of Kansas material, of which the finest and the coarsest are as follows:

	Rawlins County (finest) per cent	Hamilton County (coarsest) per cent
+20 mesh (0.833 mm.)	0.15	13.0
-20 +100 mesh (0.833 mm. to 0.147 mm.) .	3.0	39.0
-100 +200 mesh (0.147 mm. to 0.074 mm.) .	11.0	39.0
-200 +300 mesh (0.074 mm. to 0.046 mm.) .	28.0	7.0
-300 mesh (-0.046 mm.)	58.0	2.0
	100.15	100.0

Eardley-Wilmot[5] gives the following screen analysis of a sample from the Deadman River region, B. C.

	Mesh	Per cent
Retained on	35	0
	48	0.10
	65	0.30
	100	0.60
	150	0.80
	200	14.50
Through	200	83.60
		99.90

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[4] - Landes, Kenneth K., Volcanic Ash Resources of Kansas: State Geol. Survey of Kansas, Bull. 14, April 15, 1928, p. 13.

[5] - Eardley-Wilmot, V. L., Abrasives. Part I, Siliceous Abrasives: Canada Dept. of Mines, Mines Branch, 1927, p. 89.

USES

Pumice

The finest grades of pulverized pumice are used for finishing silverware, watch cases, and other kinds of metal ware. Much is consumed in the electroplating industry for cleansing, scouring, and polishing. The very finest air-floated powder is used in certain dental preparations. Pulverized pumice is also used in making mechanics' soaps, for cleaning plate glass, in the manufacture of combs, pearl buttons, in pouncing paper for finishing hats, and for cutting and beveling glass.

Ground pumice has been used widely in finishing wood surfaces, but this utilization is confined mainly to the highest grades of furniture such as pianos. About 12 years ago large quantities of pumice were used for finishing automobile bodies, but this use has diminished considerably. Some pumice is also used in tumbling barrels. Ground pumice has found some utilization in putting a linen finish on celluloid collars, but this use has been abandoned.

Lump pumice is used for hand rubbing of stone, such as marble, for rubbing down paint surfaces, for finishing automobile bodies, for finishing leather, in lithographic work, and to a considerable extent in the electroplating industry for cleaning buffing wheels. A small quantity of the highest-grade material is used as a toilet article.

The following information relating to the various grades and uses of ground and lump pumice was derived mainly from trade literature of the James H. Rhodes Co. This company, however, uses different designations for its ground material; their FFFF grade is known as No. 2600, FFF as 2601, and so on to grade 10 which they describe as No. 2613.

Ground Pumice

Grade	Mesh	Utilization
FFFF	Very finest air-floated powder	Extremely fine work.
FFF	-200	Finishing auto bodies and for certain kinds of soap.
FF	-160	Do.
F	-140	Do.
0	-100	Glass cutting and silver-plate finishing.
0½	-80	Glass beveling and piano finishing.
0¾	---	Do.

Ground Pumice (Continued)

Grade	Mesh	Utilization
0½	-60	Grades 0½ to 1½ are used for rough rubbing in piano factories; in the manufacture of combs, pearl buttons, and mechanics' soap.
1	-50	
1½	-48	
2	-40	Finishing certain kinds of pearl buttons.
3	-30	Do.
4	---	Coarse rubbing of hard materials.
7	From sand to	Used in tumbling barrels.
10	pea size	Do.

Lump Pumice

Grade	Description	Utilization
AA	Small, very finest quality.	Automobile finishing.
A	Little larger, almost same grade and quality as AA.	Do.
XXC	Size of one or two fists.	Do.
BBC	Approximately same as XXC, but inferior grade.	Do.
WW	....	Finishing stone and marble.
LIT	About 7 inches in diameter.	Lithographic work.
HP	Similar to LIT, inferior grade.	Finishing leather.
1717	Lightweight, in bags.	Electroplating work.
BD	....	Cleaning buffing wheels in electroplating industry.

Pumice has been used in the manufacture of vinegar as a porous packing material for the generators which convert dilute alcohol into acetic acid. Pumice is utilized in construction because of its light weight and its insulating properties. The manufacture of building units using pumice as aggregate has been developed much more intensely abroad than in America, although recently considerable interest has been shown in various lightweight building materials in this country. In southern Italy natural pumice is used between asphalt coatings for insulation of floors and roofs. Pumice aggregates have been used extensively in Germany in manufacturing plates, hollow blocks, and tiles for flooring. The advantages claimed for such material are lightness, heat and sound insulating qualities, incombustibility, artistic rough surface if laid up without any coating, and a surface to which plasters readily adhere if coatings are used.

Tuff has been used successfully as a building stone in Arizona and in California, and pumice stone has been utilized as a building material to

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some extent in other localities. Bricks containing pumice and cement have been manufactured in the upper Rogue River district of Oregon for a number of years.

Another use for pumice in construction is in the form of acoustic plasters. Much interest is manifest at present in the relation of sound to human comfort and efficiency. The development of radio and talking pictures, the modern trend toward apartment dwellings, increase in traffic and other city noises, and other factors have stimulated research as to how sound may be controlled, both as to its reception and its insulation.

Sound reverberation is especially objectionable in theatres, moving picture stages, auditoriums, churches, and similar places. Its control is based mainly upon proper design of interiors as to shape and size, and upon the character of the wall surface. The purpose of acoustic plaster is to absorb sound waves striking the walls, with as little reflection as possible. The value of acoustic material is dependent largely upon the character of the exposed surface itself, the material just underneath having little to do with acoustical properties. Pumice has been used in place of sand for preparing acoustic plastors and is said to have given satisfactory results. It is reported to the bureau that the sizes used for this type of work are usually minus 8 to plus 30 mesh.

Sound insulation or sound deadening material is desired for places requiring a degree of soundproofness. Radio broadcasting studios, offices, apartments, hotels, and other kinds of buildings require sound insulation in varying degrees. Pumice used in plaster or other types of material has been found to possess certain sound deadening qualities. For this work a grade of minus 10 to plus 20 mesh has been used, whereas minus 20 to plus 40 mesh has been used for interior stucco, applied directly on the base plaster. A considerable field exists for further development of both acoustic and sound deadening material.

Lormand[6] quotes Bigot as saying that pumice can be pulverized and then agglomerated with "silicates" to build "a new type of furnace for glass works, the radiation of which is very slight, and which allows work to be carried out quite close to the furnace itself, thus reducing the amount of labor necessary."

Pumicite

Pumicite is used extensively as an abrasive in cleansing and scouring compounds, in mechanics' soap and preparations of similar character. Waste vegetable oils such as cottonseed oil may be saponified and used as the soap content.

As a substitute for ground pumice, some pumicites are used in electroplating with gold, silver, and nickel, and in the manufacture of pearl buttons. Other uses as an abrasive are in tooth pastes and powders, metal polishes, and rubber erasers. It can also be molded into tablet form for household and toilet use.

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6 - Lormand, Charles, Paris Letter: Jour. Ind. Eng. Chem., vol. 13, Feb., 1921, pp. 171-172.

Pumicite is used to a considerable extent as an admixture to concrete in dams and other types of massive construction, in grain elevators, and also for general concrete work. It is claimed that 4 to 5 pounds per sack of cement added to the mix results in greater uniformity of the concrete, increases the workability of the mix, and hinders segregation of the other aggregates. The use of pumicite as a cement admixture in the construction of grain elevators is said to facilitate slipping the forms upward as the concrete work progresses.

In the construction of the Los Angeles Aqueduct pumicite was blended in equal parts by volume with hydraulic cement to make what was called "tufa cement." The details of this utilization are fully described in the Transactions of the American Society of Civil Engineers, vol. 76, 1913, page 520, and the results are summarized in the "Final Report, Construction of the Los Angeles Aqueduct," published by that city. Pumicite was also used in the Niobrara Dam at Valentine, Nebr. Besides having been employed in a number of other structures in the Western States, a considerable tonnage is reported under contract for the Los Angeles flood control district.

Pumicite has been used to some extent as an insulating material for packing steam and water pipes, for lagging boilers, and for lining cold-storage rooms. It has also been used in filter cells, in paints as a filler, and in sweeping compounds. Much of the pumicite produced is consumed by soap manufacturers who have their own specifications for the material, depending upon the product. To some extent the classification FFF, FF, F, 0, $\frac{1}{2}$, 1 and so on, which applies to ground pumice is also given to pumicite.

ORIGIN AND OCCURRENCE

Lava is a general term applied to molten rock forced out from volcanoes. Lavas range in composition from acid to basic, or from a rhyolite which consists mainly of quartz, orthoclase, microcline, or the acid plagioclase feldspars such as albite and oligoclase, to basaltic rocks which are mostly lacking in these minerals and are composed principally of labradorite and anorthite of the plagioclase feldspars, pyroxene, olivene, or other minerals less siliceous than those characterizing the so-called acid rocks.

Basic lava behaves differently from acid lava. Since a basic lava softens at a comparatively low heat and is characteristically liquid almost down to its freezing point, it will usually flow quietly from a volcano. Inasmuch as the internal prossure is relieved with little tendency for explosive eruption, pumice is rarely formed from basaltic lavas. Deposits of pumiceous basalts, however, do occur in the Sandwich Islands; such material is commonly yellow or brown in color, but may be pitch black when freshly exposed.

Acid lavas, on the other hand, melt at relatively high temperatures and are likely to be quite viscous when even slightly chilled. At temperatures which would have little effect upon a basic lava, they are apt to harden or cease to flow readily. Such stoppages in the earth's vents or safety valves (which volcanoes practically are) cause enormous pressures to build up until

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the force becomes powerful enough to break through or blow out the plugging material. This may happen with such explosive violence as to hurl enormous masses of material out from the volcano, sometimes disrupting the mountain itself and spreading destruction for miles around. Examples of comparatively recent violent eruptions that have created vast quantities of pumiceous materials are those of Mt. Pelee on the island of Martinique, Krakatoa in the East Indies, Katmai on the Alaskan Peninsula, Vesuvius in Italy, and Mt. Colima on the west coast of Mexico.

During volcanic activity different conditions favor the formation of pumice, pumicite, and various extrusive or intrusive igneous rocks. Formation of pumice requires usually a molton acid lava, highly impregnated with gases, with conditions of temperature, pressure, and extrusion such as to permit the gas to expand in the hot lava forming bubbles or threads and fibers with thin glasslike walls between the cells. The vesicles must not expand to the point of disruption, and the walls must harden rapidly enough to prevent collapse upon any release of pressure and to prevent the formation of mineral crystals. Contamination with nonpumiceous materials such as rhyolite, felsite, scoriae, and obsidian are objectionable from a commercial viewpoint. Deposits of pumice are always found near centers of volcanic activity. Some occurrences are massive and capable of yielding pumice in lump form. Other deposits of pumice are quite loosely consolidated, being in the form of sand or gravel.

Slightly different conditions such as greater pressure and consequently a greater explosive force may produce pumicite or volcanic dust. In eruptions of this character a portion of the lava may be spumed into the air in very fine particles, not unlike pulverized glass, accompanied by water vapor, gases, and fragmental volcanic rocks. Much of the dustlike matter is borne hundreds and some of it thousands of miles by air currents. Heavy particles drop relatively near the source while the finer and more buoyant material is deposited at greater distances, so that a certain classification by particle size is accomplished.

The dust may settle in water or on land and may be reworked by wind and stream action. The loose, unconsolidated material behaves much like drifting snow or sand, and much of it is eventually carried away by streams. It may, however, drift into natural land depressions where it is subsequently buried. Deposits in the older geological formations are often too greatly contaminated with impurities to be of commercial importance at present. Some deposits are found in old lake beds and may contain silt, clay, skeletons of diatoms, and other fossil material. Again they may be covered by lava flows or other volcanic formations, and where deposition has been in shallow seas, lakes, or ponds, the pumicite beds may become buried under sedimentary strata. Many of the commercial deposits even in Kansas, Nebraska, and Oklahoma are lens-shaped, grading laterally into sand or loess. They also contain islands of other material and are usually covered by loess, sand and gravel, or soil.

Extinct volcanoes in the Rocky Mountain region are thought to have been the source of pumicite in the States of the Great Plains region, and probably a number of volcanoes contributed to these deposits.

Pumiceous material is abundant in red clay found in ocean deeps. Although some may have been formed from submarine volcanoes, most of it probably was deposited on the surface of the ocean and sank as it became waterlogged. Floating deposits of such material, as much as 5 feet thick, have been reported after violent volcanic eruptions.

DEPOSITS IN THE UNITED STATES

Commercial deposits of pumice and pumicite occur in California, Kansas, Nebraska, Nevada, Oklahoma, and many other Western States. No attempt is made here to list all potential or undeveloped deposits of pumicite. Volcanic materials are abundant in many of the Western States, and vary in texture from the hard dense lava flows to the true pumice and pumicite. Much of the material is associated with tuffs of all kinds, which include the induratod pumicite, scoriae, and other materials peculiar to volcanic formations. The occurrences described in the following paragraphs include only those in districts from which production of pumicite has been reported to the bureau, or about which definite information is available as to characteristics.

Arizona. - Commercial deposits of pumicite occur in Yuma County near Bouse.

Arkansas-Louisiana. - Beds of volcanic tuff occur in the Cretaceous and Tertiary formations of this region. The material is encountered in deep wells and is useful only in so far as it forms key beds that aid in the proper correlation of other geological formations.

California. - Pumiceous material occurs in many counties in California, but pumicite is produced mainly from Fresno, Mono, Kern, and San Luis Obispo Counties. Siskiyou, Inyo, Mono, and Imperial Counties are the more important sources of pumice.

Colorado. - Deposits of pumicite of varying grades are abundant in the eastern part of Colorado.

Iowa. - A bed of pumicite 1 foot thick has boen reported from Des Moines, occurring below the Wisconsin glacial drift and above the Peorian loess. This material appears to be only of scientific interest, perhaps indicating the eastern limits of the pumicite in the Great Plains region.

Kansas. - Extensive deposits of pumicite from 16 to 20 feet thick are worked in Meade County near Fowler. Over the pumicite is about 15 feet of sand and soil overburden. Other deposits occur in Shendan, Norton, Rawlins, and Seward Counties. Minor occurrences have been found in many other counties of the State, some of which have yielded small tonnages.

Montana. - Pumicite occurs in many counties of Montana, the more extensive deposits being in Gallatin County where the material occurs in layers about 5 feet thick between impure beds of pumiceous material, the entire formation having a thickness of 100 to 1,000 feet.

Nebraska. - At one time Nebraska led in the production of pumicite, but the industry has lagged considerably since the development of the Kansas deposits. Pumicite is found in nearly every county of the State and, as in Kansas, coarse material occurs in the western part and fine material to the east. Most deposits are overlain by a mantle of loess which has been partly removed by erosion. Deposits are worked in Frontier County; other important deposits occur in Harland County.

Nevada. - Extensive deposits of pumicite occur in Nevada, but so far there has been little production from this State.

Oklahoma. - A number of deposits have been found in Oklahoma, but little if any pumicite is being produced at present. The largest occurrences are in the northeastern part of the State near Gate close to the boundary of Harper and Beaver Counties, where a thickness of 80 feet has been reported. Other deposits have been found west of Woodward, northeast from Custer City, and northwest from Wetunka, where a small tonnage has been produced. Buttram[7] reports deposits in Beaver, Harper, Woodward, Woods, Blaine, Custer, Kay, Okfuskee, Hughes, and Haskell Counties.

Oregon. - Pumicite occurs in eastern Oregon and important deposits are found in the valley of the Deschutos, Klamath, and Umatilla Rivors.

South Dakota. - A commercial deposit of pumicite occurs at Winner in Tripp County; it is utilized in the manufacture of powdered soap.

Texas. - A deposit of pumicite has been reported from Dickens County, 50 miles northwest from Double Mountain.

Washington. - Pumicite has been reported from the vicinity of various volcanic peaks such as Mount St. Helena.

Wyoming. - A deposit of pumicite 4 feet thick has been reported near Sportsman Lake 8 miles west of the station of Tie Siding on the Union Pacific Railway.

DEPOSITS IN CANADA

Extensive beds of pumicite occur in the vicinity of Waldeck, Saskatchewan, on the Canadian Pacific Railway, 11 miles northeast of Swift Current. British Columbia has reported pumicite from Dead Man's River, Arrow Lake, Haig, and Elko.

MINING

Pumice and pumicite are mined both by surface excavations and underground methods, but for operations handling a large tonnage, open-pit methods generally have been adopted. Where open-pit methods are employed the overburden, which usually is loess, sand, or soil, is removed by hand, team and scrapers, or power shovels. In some operations a thin layer of overburden is left to protect the underlying pumicite until it is mined. At other deposits the entire thickness is removed from as much of the area as may be required. The pumicite is then dug by pick and shovel, loaded into wagons, and carted to the mill or to the shipping point. Power shovels are used in some operations. Little or no blasting is required.

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[7] - Buttram, Frank, Volcanic Dust in Oklahoma: Oklahoma Geol. Survey, Bull. 13, Dec., 1914, p. 34.

At the operations of the Pumicite Co., Fowler, Kans., overburden consisting of 8 to 10 feet of soil is removed with a 1-ton Lorraine gasoline shovel. Hand shovels are used to clean up the surface of the exposed pumicite, which is subsequently mined in much the same manner that the overburden is removed. Animal burrows, filled with dirt and clay, are found in the beds of pumicite and must be carefully separated.

The Fresno Estate Co., Fresno, Calif., with deposits on the McKenzie Ranch about 3 miles from Friant on the Southern Pacific Railroad, mines pumicite by drifts into the dome-shaped hills, which rise about 80 feet above the general ground level. These domes are virtually solid pumicite, except for about 4 feet of overburden. No explosives are used in the mining, which is done by pick and shovel.

PREPARATION FOR MARKET

Milling operations consist essentially in freeing the individual particles from one another, removing excess moisture, eliminating impurities such as clay, concretions and other harmful substances, grading the pumicite particles to the sizes desired, and packing for shipment.

At the pumicite deposits of the Middle West little or no crushing or grinding is necessary to free the pumicite grains. At the operation of the Cudahy Packing Co., in Meade County, the pumicite is shoveled by hand from the quarry floor into wagons, which transport the crude material to the mill. There it is dumped or shoveled into hoppers and then fed into an inclined oil-burning rotary kiln where the water, which may be as much as 20 per cent of the weight of crude material, is driven off. The dried pumicite is passed through a revolving 5-mesh screen to air separators. The oversize from the screen and the overweight from the air separators are rejected. Graded pumicite is packed in paper-lined freight cars and shipped to Chicago, where 2 per cent of soap is added to make a well-known cleansing compound.

At Fowler, Kans., the pumicite is taken from the pits to the mill (which has a capacity of 100 tons a day) and proceeds successively through a pan pulverizer, rotary oil-fired driers, Tyler Hum-mer screens, and a Bates packing machine. The product grades 90 per cent through 200 mesh, reject from the screens being returned to the pan pulverizor. Two rotary driers are used, each being 6 feet in outside diameter. One is 26 and the other 52 feet long. The inner compartment consists of a chamber the length of the drier, but 30 inches square in cross section. This shape has been found most suitable for handling and drying the pumicite, the square section having a tendency to break up the material and to prevent rotational slippage.

Bulk crude pumicite may be shipped in paper-lined box cars, but most of the prepared or refined material is packed in 3-ply paper sacks weighing 40 pounds each.

The La Rue-Axtell Pumice Co., Eustis, Nebr., mines its material in open pits. The first step in milling is to remove the moisture in rotary shell driers, both coal and distillate having been used for fuel. The material is subsequently screened to sizes varying from 40 to 90 per cent through 250 mesh. The pumicite is packed for shipment in paper bags of 75 pounds, burlap bags of 100, 150, or 200 pounds, or in barrels of 300 to 350 pounds capacity.

At Fresno, Calif., crude material is passed through a revolving cylinder equipped with paddles, which pulverize the lumps. This single mill operation produces a powdered product of which 98.8 per cent will pass a 325-mesh screen. Only one grade of pumicite is produced, most of which is used in concrete. Shipments are made in bulk and in 80-pound burlap sacks.

The California Quarries Corporation, with quarries at Tom, Mono County, Calif., mines pumice from a hill deposit with a gasoline shovel. The pumice occurs mixed with quartz sand which is removed by passing the crude material over dry concentrating tables. The separation is quite easily made because the pumice, due to its porous structure, is lighter than the sand. Pumice from the concentrating tables is screened to the desired sizes, the oversize being passed through a system of roll crushers. Pumice that is used with gypsum for plaster work is dried in rotary driers, packed in burlap sacks of 80 pounds each, and transported by an overhead tram to a warehouse on the railroad.

Virtually all sizes of pumice, from ½ inch to minus 60 mesh, are produced. Most of the product is used in acoustic plaster and is sized to minus 8 and plus 30 mesh. Sizes plus 8 and minus 30 mesh are used for concrete work.

Most domestic pumice and pumicite is prepared for market in the Middle West or West, whereas much of the Italian pumice imported for domestic consumption is milled in the East. American-ground Italian pumice is prepared from small pieces of high-grade material (pezzame) which is shipped in bags to America for further preparation.

In the plant of the James H. Rhodes Co., at Dutch Kills Canal, Long Island City, N. Y., bags of pumice are transferred from lighters and dumped into a large elevator pocket. This material has already had a preliminary sorting and grading, impurities such as obsidian, particles of iron, and inferior grades of stone having been removed at the island of Lipari. After being elevated to storage bins the material is crushed, screened and subsequently carefully dried. The pumice is then sent through a series of bolting machines where it is sifted through Swiss silk and sized to the various desired grades. Patented machines are used to pack the material for shipment in barrels lined with crinkled paper.

DOMESTIC PRODUCTION

The following production figures of pumice and pumicite sold or used by producers in the United States, 1920 to 1930, have been compiled by Miss A. E. Davis of the United States Bureau of Mines.

Pumice and Pumicite Sold or Used by Producers in the United States, 1920-1930

Year	Short tons	Value	Value per short ton
1920	41,838	$114,433	$2.74
1921	37,108	158,540	4.27
1922	45,262	175,600	3.88
1923	56,575	214,169	3.79
1924	43,651	190,253	4.36
1925	40,380	179,020	4.43
1926	53,887	208,504	3.87
1927	53,298	221,481	4.16
1928	57,430	278,516	4.85
1929	67,013	353,064	5.26
1930	56,843	336,099	5.91

IMPORTS

More than 90 per cent of all pumice imported into the United States comes from Italy, where it is mined in the Lipari Islands just north of Sicily. Germany is second in importance, and imports from other countries are virtually negligible. Imports of pumice for consumption from 1919 to 1930 are given in the following tables:

Imports for consumption: Crude or Unmanufactured Pumice Valued at $15 a Ton or Less, 1919-1930

Year	Rate of duty	Quantity, long tons	Total value	Value per long ton
1919	5 per cent	4,044	$26,003	$6.43
1920	do	7,992	53,067	6.64
1921	do	2,216	15,180	6.85
1922 (Jan. 1-Sept. 21)	do	4,881	34,362	7.04
1922 (Sept. 22-Dec. 31)	1/10 cent per pound	2,516	17,714	7.04
1923	do	10,868	71,730	6.60
1924	do	7,995	70,977	8.88
1925	do	8,457	86,992	10.29
1926	do	8,371	85,141	10.17
1927	do	7,821	85,591	10.95
1928	do	9,206	94,804	10.30
1929	do	8,310	84,718	10.19
1930	do	5,570	55,014	9.88

Imports for Consumption; Crude or Unmanufactured Pumice Valued at More Than $15 a Ton, 1919-1930

Year	Rate of duty	Quantity, long tons	Total Value	Value per long ton
1919	5 per cent	1,190	$47,617	$40.01
1920	do	2,387	90,711	38.00
1921	do	371	13,569	36.57
1922 (Jan. 1-Sept. 21)	do	650	21,680	33.35
1922 (Sept. 22-Dec. 31)	¼ cent per pound	47	1,557	33.13
1923	do	125	5,970	47.76
1924	do	109	5,129	47.05
1925	do	598	11,600	19.40
1926	do	190	5,745	30.24
1927	do	151	4,783	31.68
1928	do	704	18,654	26.50
1929	do	323	11,056	34.23
1930	do	240	9,312	38.80

Imports for Consumption: Pumice Wholly or Partly Manufactured, 1919-1930.

Year	Rate of duty	Quantity, long tons	Total Value	Value per long ton
1919	¼ cent per pound	1,975	$44,692	$22.73
1920	do	3,948	103,683	26.26
1921	do	948	19,170	20.22
1922 (Jan. 1-Sept. 21)	do	1,954	31,095	15.91
1922 (Sept. 22-Dec. 31)	55/100 cent per pound	886	11,414	12.88
1923	do	2,504	48,194	19.25
1924	do	2,425	33,781	13.93
1925	do	2,670	30,873	11.57
1926	do	2,753	36,843	13.38
1927	do	2,009	32,019	15.94
1928	do	3,825	43,471	11.36
1929	do	4,051	46,838	11.56
1930	do (a)	3,158	29,673	9.40

(a) Effective June 18, 1930, the duty on wholly or partly manufactured pumice was advanced from 55/100 cent per pound to 3/4 cent per pound.

Imports for consumption: Manufactures of Pumice, or Manufactures of which Pumice is the Component Material of Chief Value, 1919-1930

Year	Rate of duty, per cent	Quantity, long tons	Total value	Value per long ton
1919	25	.....	$1,469	......
1920	25	.....	2,534	......
1921	25	.....	3,586	......
1922 (Jan. 1-Sept. 21)	25	.....	636	......
1922 (Sept. 22-Dec. 31)	35	9.38	836	$92.88
1923	35	18.32	2,709	152.78
1924	35	12.40	1,397	112.66
1925	35	4.77	995	208.59
1926	35	.....	1,720	......
1927	35	.....	1,681	......
1928	35	.....	2,507	......
1929	35	.....	1,332	......
1930	35	.....	388	......

TARIFF

The tariff act[8] of 1930 makes the following provisions for duties on pumice stone:

> Pumice stone, unmanufactured, valued at $15 or less per ton, one-tenth of 1 cent per pound; valued at more than $15 per ton, one-fourth of 1 cent per pound; wholly or partly manufactured, three-fourths of 1 cent per pound; manufactures of pumice stone, or of which pumice stone is the component material of chief value, not specially provided for, 35 per centum ad valorem.

ITALY

Vesuvius has been the source of much of the Italian pozzuolana cement, so named from the town of Pozzuoli near Naples. The cement was made in part from pumicite and was used extensively in constructing the famous Roman walls, aqueducts, and other historic structures. The Roman Pantheon, more than 2,000 years old, is a striking example of the durability of this kind of construction. The old Roman harbor works at Porto Trejano, Porto d'Anzio near Rome, and Porto Adriano near Bari are examples of this kind of cement used as hydraulic material. The practice of using pozzuolana materials was revived about 1882, and the results are said to have been uniformly satisfactory since 1888.

The pumice exported to the United States, however, comes from high-grade deposits on the barren and relatively inaccessible island of Lipari about 22 miles from the northern coast of Sicily. The best material occurs along the eastern and northern coasts in the vicinity of Canneto where American-owned mills and warehouses are located.

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[8] - Tariff Act of 1930, par. 206, p. 15.

High-grade pumice occurs in flat-lying veins or beds with related material known locally as "lapillo." Mining pumice by picks and shovels in excavations on the surface or underground by means of rude drifts and crosscuts, has been the occupation of the natives for many years and is their only means of livelihood at present. Little, if any, timbering is done, and individual workings are quite apt to cave before all available pumice can be removed. Men, women, and children engage in the work, toiling from 12 to 14 hours at wages that range from 20 to 40 cents a day. The pumice is loaded into baskets and carried to the women and children who sort the chunks into various grades.

Although some lump pumice is exported in the crude state, most of it is smoothed with files. Pieces smaller than 4 inches and sometimes larger ones of hard and inferior quality are rolled in heavy tin-plate cylinders. The highest grade lumps are wrapped in tissue paper, and packed with excelsior in wooden boxes and casks of 220 pounds (100 kilograms) or in barrels of 330 pounds (150 kilograms).

Smaller fragments of $\frac{1}{2}$ inch to $1\frac{1}{2}$ inches in size may be sold direct by miners to exporters. This material is commonly called "pezzame." It is packed for export in jute bags of from 88 to 176 pounds (40 to 80 kilograms). The greater part of it comes to the United States where it is ground for American trade. Some Italian ground pumice consists of very fine material screened in a primitive fashion at Lipari. A large proportion is of an inferior grade, consisting mainly of lapillo, although some is ground from smaller fragments of high-grade pumice.

At the mines, lapillo is dumped into long wooden chutes, from which it falls through screens. To be classed as powdered pumice, it must pass through a screen not larger than 20 mesh. Coarser than 5 mesh is grinding rock, while minus 5 and plus 20 mesh is termed "rasaglia," most of which is commonly rejected as being too small to handle profitably; some, however, is manufactured or ground. After the first rough screening the lapillo must be either sundried or heated over coal ovens to facilitate bolting. The bolting machines are hexagonal wooden wheels about 10 feet long and 3 feet in diameter and are equipped with wire screens of from 35 to 200 mesh. Hand power generally is employed for turning these wheels, but sometimes steam or oil engines are used.

Pumice is known by a number of local or Italian names applied to the various grades and sizes of lump material. Pomice grossa or grosse are the largest lumps from 4 to 8 inches in size. This grade is subdivided to fiore, quasi-fiore, and mordente, which are three grades of superior material; and bianche, dubbiose, and mere, which are three grades of inferior stone. Correnti is medium size and pezzame is smaller fragmental material. Bastardoni is medium lump and may be applied to very hard, heavy pumice usually 4 to 8 inches in size. Rasaglia and alessandrina are smaller pieces somewhat similar to pezzame. Pietra pomice in pizzi is the general term applied to lump pumice, whereas pietra pomice polvere applies to powdered pumice stone. Lapillo is pumice dust or detritus, a fine powder occurring mixed with pezzame and rasaglia.

GERMANY

Trass is a cement made from a form of indurated pumicite occurring in the Eifel region of Germany. The material resembles soft stone which has been weathered considerably since deposition. In composition it is quite similar to pumicite of other localities.

Pumice sand and gravel occur in the Neuwied Basin in the Rhine Valley of Germany. The material is said to be very porous, light in weight, and to possess good insulating qualities. The composition varies from 55 to 70 per cent of SiO_2, 15 to 20 per cent of Al_2O_3, with about 14 per cent of potassium and sodium salts.

In the manufacture of building units the practice originally was to mix pumice sand with clay and milk of lime. The mass was then moulded and air-dried to make what were called floating stones; these were used locally at first, but in 1911 it is reported that 320,000,000 units were shipped to outside markets. The industry slumped during the World War but has been revived in recent years. Cement and quick-setting limes have largely replaced the cementing agents formerly used, and many other improvements have been made in manufacturing processes. To a certain extent the industry has felt competition from slag, clinker, and other materials.

According to an article appearing in Cement, Lime and Gravel, January, 1930, more than 600 factories produce various kinds of building material in which pumice is used. Automatic machinery is being installed which will make upwards of 3,000 bricks an hour. Many houses, offices, warehouses, factories, hospitals, barracks, churches, theatres, and other structures have been built with similar units. The following advantages are claimed: The material is of a highly porous character, very light, and resists frost. It is fireproof, and does not expand or contract appreciably, and because of its lightness and strength the steel framework can be lighter, which saves an expenditure of as much as 15 per cent in cost, to say nothing of the reduced cost for cartage and freight. On account of the lightness of the material a builder can handle and place in position at least 25 per cent more bricks a day.

The units are good sound insulators and are used largely for flooring with reinforced steelwork.

> Pumice stone is very porous and gives a natural ventilation to the walls of a building. No dry-rot or mouldy fungus is possible where pumice stone is used. Pumice-stone building material is square edged and gives a perfect bond for mortar or other binding agent. For plaster work no laths are required, and one coat of plaster is sufficient. Nails can be driven into pumice stone blocks and the material can be sawn. Pumice-stone building material will be found to have advantages for constructing agricultural

and fruit and farm buildings. The porous nature of the material gives natural ventilation, which allows fruit and farm produce being kept under improved conditions. Clean pure air is necessary for dairies and stables and it is claimed that cattle and horses are much more comfortable and healthy when housed in buildings made from pumice stone. There is no wall sweating with this new material.

AUSTRIA

Important deposits of pumice occur in the Tyrol district of Austria.

NEW ZEALAND

Deposits of pumicite as thick as 20 feet occur in southeastern New Zealand in the Gisborne district in the vicinity of Poverty Bay. Eardley-Wilmot[9] states that the annual production is between 2,000 and 4,000 tons.

JAPAN

Pumice stone used for boiler and furnace insulation, and known locally as koka seki, occurs on the Niijima Islands 90 miles south from Tokio.[10]

OTHER COUNTRIES

Volcanic material suitable for use in cement, occurring in southeastern France and the Azores, has been shipped to Portugal for river and harbor work and general construction. A pumicite, locally called tosca, is shipped from the Canary Islands to Spain. Santorin, a pumicite from the island of Santorin in the Grecian Archipelago, was used in the construction of the Suez Canal.

MARKETS AND PRICES

Domestic pumice and pumicite, and imported Italian pumice offer individual marketing problems because of differences in geographical source, physical properties, preparation for market, and utilization. Pumicite enters quite different markets from either lump or ground pumice, although there is an overlapping in certain forms of ground pumice stone used for scouring soaps, cleansing compounds, and a few other abrasive uses. As a rule, however, domestic pumicite is a different grade of material, commanding a lower price.

Certain of the largest pumicite consumers, manufacturing scouring and cleansing compounds, operate their own deposits and are seldom in the market for outside material. Pumicite used in large construction jobs is commonly sold on a contract basis. Only a relatively small quantity is sold through jobbers and dealers. Because of these conditions the open market for pumicite is relatively small and prices for sales are not available. From the value of production reported to the Bureau of Mines, however, a unit price per ton on all pumicite produced can be calculated. For 1930 this price was slightly less than $6.

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[9] - Eardley-Wilmot, V. L., Work cited, p. 91.
[10] - Eardley-Wilmot, V. L., Work cited, p. 83.

As regards future trends, the only clues are furnished by the records of the past. During the last 10 years domestic production of pumicite has increased about 30 per cent in volume. Because of the constantly changing fabric of our civilization many old uses have diminished in importance, but such losses have been offset by the development of new uses. The use of pumicite in concrete and in the manufacture of cement may be of more importance in the future than it has in the past.

At present, marketing of pumicite is dependent quite largely upon specific demands, and new operators should study markets thoroughly before investing any considerable capital.

The growing demand for building materials possessing special properties for specific purposes perhaps offers one of the most promising potential markets for pumice and pumicite. American producers will do well to keep in touch with practice in Europe, where this branch of the industry has been developed much more intensively than in the United States.

Much of the domestic pumice, produced largely in California and Oregon, is ground and used similarly to pumicite. Some is used in various construction ways. Most of it, so far, has been utilized locally; it has not yet been able to penetrate successfully the ground-pumice markets in the industrial eastern United States, except for a short time during the World War when material from Italy was not available. During war times some consumers were able to use domestic supplies, whereas others found such material not up to the standards of the imported pumice. It is difficult to ascertain whether this dissatisfaction was due to differences in quality of raw stock, insufficient or perhaps careless preparation, or unjustified prejudice against an untried product. It is reported that a new attempt is being made to place western ground pumice on the eastern market in competition with imported material.

Pumice imports have remained fairly constant during the past 10 years. Most of the business has passed into the hands of a few manufacturers and dealers, resulting in higher standards of quality, better service to the consumers, and less confusion as to grade of material bought. Foreign pumice is of two kinds, American ground and Italian ground, the former being considered much superior in abrasive qualities, uniformity of grain size, and general utilitarian value.

American-ground Italian pumice which is pulverized, sized, and packed in bags in the United States sells for $30 or more per ton f.o.b. mill, New York, price depending upon grade and quality. Coarse sizes are higher in price than fine sizes. Prices for materials in bags are somewhat less than for that packed in barrels.

Italian-ground pumice is lower in cost than the American-ground Italian variety. One importer reports that Italian-ground material can be delivered c.i.f. Atlantic port for $10.50, which makes the delivered cost around $25.50 including the duty of $15 per short ton. On the other hand, pezzame or small lump pumice such as is used as raw material for American ground pumice, costs about $18.50, including the duty of $2 per short tons. Other grades of lump pumice are still higher priced, running from 1.7 cents to 14.1 cents per pound, plus a duty of 25 cents for unmanufactured or 75 cents for manufactured pumice per 100 pounds. Prices vary according to quality and degree of preparation.

LIST OF PRODUCERS

The companies producing pumice and pumicite in the United States in 1930 and the locations of the deposits from which the pumice and pumicite were obtained were as follows:

Location of Deposit	Name and Address of Company
Arizona:	
Yuma County, Bouse	Yuma Products Manufacturing Co., 3648 Humboldt St., Denver, Colo.
California:	
Fresno County, near Friant	Earlonite Mining Co., Box 474, Selma, Calif.
Do.	The McKenzie Estate, Griffith-McKenzie Bldg., Fresno, Calif.
Imperial County, near Calipatria	A. W. Brand, 880 E. Colorado St., Pasadena, Calif.
Do.	Kalite Co. Ltd., South Oak Knoll Ave., Pasadena, Calif.
Imperial County, Niland	Flynt Silica & Spar Co., 1047 Richmond St., Los Angeles, Calif.
Inyo County, Shoshone	Chas. Brown, Shoshone, Calif.
Do.	California Talc Co., 837 Jackson St., Los Angeles, Calif.
Do.	Tonopah & Tidewater Railway, 1014 Central Bldg., Los Angeles, Calif.
Kern County, Saltdale	Cudahy Packing Co., 111 West Monroe St., Chicago, Ill.
Mono County, near Laws	California Quarries Corporation, 1300 Quinby Bld Los Angeles, Calif.
San Bernardino County, Daggett	Hill Brothers Chemical Co., 2159 Bay St., Los Angeles, Calif.
San Luis Obispo County, near Paso Robles	M. L. Francis, R. F. D., Creston, Calif.
Kansas:	
Grant County, Santanto	H. H. Zimmerman, Adams, Kans.
Meade County, Fowler	Cudahy Packing Co., 111 West Monroe St., Chicago, Ill.
Do.	The Pumicite Co., 4025 Clara Ave., St. Louis, Mo.
Norton County, Calvert	The Davidson Pumice Co., Norton, Kans.

Nebraska:	
Frontier County, Eustis	La Rue-Axtell Pumice Co., Eustis, Nebr.
South Dakota:	
Tripp County, Winner	Klenit Corporation, Winner, S. Dak.

LIST OF BUYERS

The following are some of the more important buyers of pumice and pumicite, particularly for abrasive use:

Los Angeles Soap Co., 617 East First St., Los Angeles, Calif.
Allied Industrial Products Co., 124 N. May St., Chicago, Ill.
Cudahy Packing Co., 111 West Monroe St., Chicago, Ill.
Holman Soap Co., 3104 Fox St., Chicago, Ill.
Matchless Metal Polish Co., 842 W. 49th Place, Chicago, Ill.
Mineral Soap Manufacturing Co., Lowell, Mass.
Leon Hirsh & Son, 368 Greenwich St., New York, N. Y.
Charles B. Chrystal Co., (Inc.), 11 Cliff St., New York, N. Y.
Stanley Dogget (Inc.), 1 Cliff St., New York, N. Y.
A. Klipstein & Co., 11 Darrow St., New York, N. Y.
Whittaker Clark & Daniels (Inc.), 245 Front St., New York, N. Y.
Mr. Jerome Alexander, 50 East 41st St., New York, N. Y.
Rome Soap Manufacturing Co., Rome, N. Y.
Larkin Co. (Inc.), 680 Seneca St., Buffalo, N. Y.
The DuBois Soap Co., 1120 W. Front St., Cincinnati, Ohio.
National Sales (Corporation), 31-35 East 13th St., Cincinnati, Ohio.
Chas. W. Young & Co., 1247 No. 26th St., Philadelphia, Pa.
Charles A. Wagner Co. (Inc.), 814 Noble St., Philadelphia, Pa.

LIST OF IMPORTERS

The following firms are among the more important importers of pumice, and due acknowledgment is made for their cooperation in assembling information on foreign material.

James H. Rhodes & Co., 153 W. Austin Ave., Chicago, Ill.
Charles B. Chrystal (Inc.), 11 Cliff St., New York, N. Y.
K. R. Griffiths & Co. (Inc.), 110 East 42nd St., New York, N. Y.
Hammill & Gillespie (Inc.), 225 Broadway, New York, N. Y.
Whittaker Clark & Daniels (Inc.), 245 Front St., New York, N. Y.